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**Karen Barad's quantum ontology and posthuman ethics:
Rethinking the concept of relationality**

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Abstract

This article focuses on Karen Barad's quantum ontology and her attempts to reformulate the concept of relationality. The aim is to show how Barad's work articulates a new kind of empiricism for the social sciences, by reclaiming the creative and speculative force of experimental practice, and by re-centering the philosophical problem as a source of inquiry. Relationality is redefined through discussions of diffractive apparatus, more-than-human performativity, and the "polymorphous perversity" of the matter-meaning mixture.

Introduction

In her renowned study of Niels Bohr's quantum physics, Barad (2007) attempts to recast the relationship between scientific method and concept, claiming that "Bohr's unique contribution is this: he proposes that we understand concepts to be specific material arrangements of experimental apparatuses" (Barad, 2010, p.253). The concept is thus neither a universal ideal *instantiated* in the material plane nor a social construct *abstracted from* the material plane. Concepts are thus not immaterial, detached codes for sorting and naming activity. Nor are they mere distorted reflections of the world, a perspective that feeds into an "aggrieved postmodern antirealism." (Sheldon, 2016, p.10). The apparatus is not an unfortunate intervention in our uncertain fumbling toward more accurate expressions of conceptual content. Instead, concepts are "specific material arrangements of experimental apparatuses." In other words, concepts are working material assemblages rather than pure forms subject only to recognition, imposed on formless and inert matter. Her approach aims to encounter and engage with the *conceptual* on the material plane; in other words, this approach refuses the ontological dualism between matter and meaning - concepts are material, and matter is conceptual.

And yet, as Barad (2007) demonstrates, quantum ontology entails an entirely new conceptual mixture. She tracks the gradients and singularities of this mixture in the actual quantum *experiments* performed by Bohr and others, carefully examining the experimental event for how particular quantum concepts thrive and mutate. In other words, she looks to *experimental practice* to show how scientific research entails a particular metaphysics. Rather than borrow concepts from physics and use them as codes for describing social activity, *she shows how science does philosophy*. In order to queer the matter-meaning binary, she gets *inside* the experiments, unpacking the specific material arrangements to make visible the ever-changing conceptual dimension of matter.

In this article, I take up critical interpretations of her work – primarily Harman (2016) and Žižek (2012) – in order to better articulate her quantum ontology. My aim is

to show how her work articulates a new kind of empiricism for the social sciences which involves (1) reclaiming the creative and speculative force of experimentation, as a way of reconfiguring our concept-matter mixture, (2) recentering the philosophical problem as a source of inquiry, and (3) mapping a more-than-human quantum relationality.

Diffractional apparatus

Barad's work presents a model for how we might reclaim an experimental practice in the social sciences, as a means of reconfiguring the concept-matter mixture. She directs our attention to *diffractional apparatus* – that is, to devices for investigating ontological questions about quantum causality, temporality, relationality and life. A diffractional apparatus is designed to produce evidence about our shared quantum ontology. As such, it must occupy or interfere with a plane of generative philosophical problems – it must function as a “device” that helps us plug into problems such as: how do we live post-quantum causality? How do we mesh sub-atomic and organic temporality? In what ways must we reconceive the very notion of relationality in light of quantum science? Experiments that pursue these questions explicitly, that is, interventions that seek (unapologetically) to investigate our shared quantum ontology, recenter philosophical problems as a source for inquiry in the social sciences. Thus diffractional apparatus are different from conventional interventions because of this focus on profound philosophical problems about the quantum relationship between matter and meaning.

Barad takes from Bohr the term “phenomenon” to describe the mutual entailment (or inseparability) of (1) the observed and (2) the agencies of observation. Lenz-Taguchi (2010) demonstrates how this inseparability helps education researchers study more accurately the intra-activity of learning. Barad adopts the term “diffraction” from optics, and contrasts it with another optical term, reflection, as two competing ways of studying phenomenon. Diffraction patterns in optics are traces of intersecting waves of light, showing overlapping disturbances of two or more waves. Mazzei (2014) uses this concept to track the way that different theories collide and interact like waves, creating diffractional patterns and new insights about phenomenon. Barad borrows from Haraway (1997) the philosophical use of this term diffraction to study the shifting patterns that hold in an indeterminate world:

Diffraction patterns record the history of interaction, interference, reinforcement, difference. Diffraction is about heterogeneous history, not about originals ...
Unlike reflections, diffractions do not displace the same elsewhere, in more or less distorted form, thereby giving rise to industries of metaphysics ...
Diffraction is a narrative, graphic, psychological, spiritual, and political technology for making consequential meanings. (Haraway, 1997, p. 273)

Insofar as an experiment involves a diffractional device, the experiment becomes a means of mutating concepts and re-assembling the world. Such an experiment has consequential meaning, and cannot be described as simply a means to test hypotheses. Experiments are significant when they achieve this kind of ontogenetic re-assembling of the world. Experiments may prove or disprove a scientific claim, and surely do quite often, but they also enlist all sorts of material forces and mutate all entangled concepts.

They make a difference, a “consequential meaning,” as Haraway would say. Experiments are risky creative events that re-assemble the world. To suggest that their role is to simply determine the truth or falseness of a claim is to demote the materiality of the experiment, treating the apparatus as merely that which serves to (in)validate the conceptual content associated with the hypothesis. A closer inspection of the experimental tradition, from Galileo onward, shows how experiments *that make a difference* entail more than simply testing hypotheses.

Thomas Young performed the seminal “two-slit” experiment in 1801 to explore the wave and particle nature of light. The apparatus directs light through two slits in one screen, and then a pattern of light is generated on the second screen. A scatter pattern indicates particle behavior, while a series of solid lines indicates wave behavior because such lines occur when the waves of light (with definitive wavelength) intersect and amplify (like waves in water). This solid line pattern is called a diffraction pattern. Modern modifications of the double-slit experiment show that both light *and matter* manifest behavior of both waves and particles, and do so according to the fundamentally probabilistic nature of quantum phenomena.

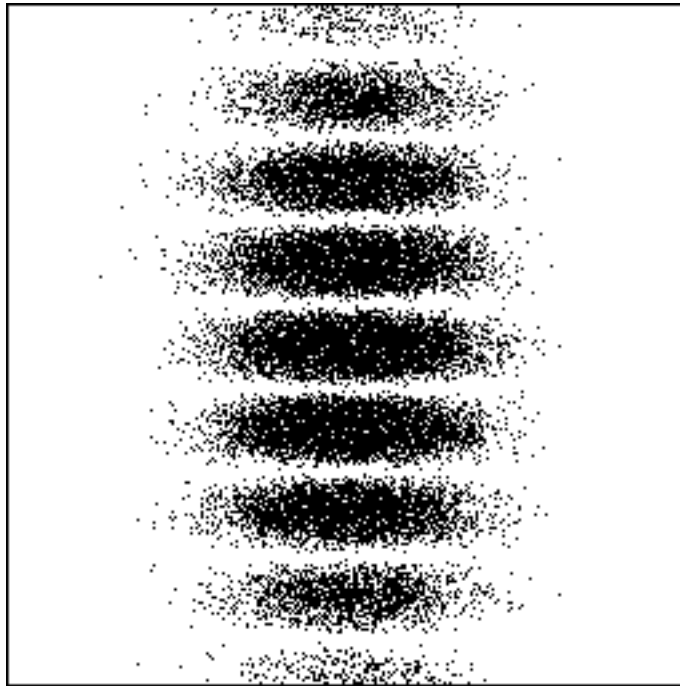


Figure #1: Diffraction pattern

Einstein was critical of the particle-wave duality theory of matter, and in an effort to show how the theory would lead to contradictions, proposed the “which slit” thought experiment. The thought experiment involves altering the apparatus slightly, so that the initial light source is measured in such a way that one could detect whether a photon was directed to one slit or another. For Heisenberg, this thought experiment pointed to how our intervention in the apparatus “disturbs” the behavior of the photons, that is, disturbs what would have happened in the absence of such an interference. For Heisenberg, quantum physics shows us the limits of our knowledge, the epistemological limits of what we are able to experience or understand. For Bohr, on the other hand, according to

Barad, the thought experiment shows exactly what he claimed – that matter can be either particle or wave, depending on the apparatus with which it is assembled. In other words, there is not a determinate thing (the unit of matter) that was being observed or capable of being observed at a particular instant. The very notion of observation is put in motion and assembled into the event-nature of the world. Human activity is *implicated* in the ontology of the atomic world, but not simply in terms of an intrusive observation that disturbs what would otherwise have some determinate or unified or fixed behavior (wave *or* particle). Rather, there are no separable isolated entities that can be observed from outside, and thus “entities” do not have a fixed inherent nature (wave or particle). Duality of wave and particle – and *indeterminacy more generally* - is inherent to matter. This indeterminacy is “in” matter (or simply *is* matter).

Not only does quantum physics undermine the notion of a determinate entity (an entity with determinate spatial boundaries), whereby one body is always spatially entangled with another, but entanglement occurs along the time dimension as well. Barad explains how this works using another famous experiment, the *eraser experiment*, which further develops the *which-slit experiment* by erasing the trace of the photon at the slit *after* it has passed through the slit; that is, by deleting any documented evidence of the fact that we knew which slit it went through. A second (even weirder) eraser experiment deletes this information *after* the scattering pattern on the screen is produced, seemingly further along time’s arrow.

If the which-slit information first “caused” the photon to create a particle pattern, and we then erase that information (before or after the photon hits the screen), the pattern alters and becomes a diffraction pattern. Hence, deleting information seems to change, retroactively, the “nature” of the original matter (that nature being particle or wave). This experiment shows how time and not just space is entangled in the apparatus, undermining time’s arrow, and troubling the very idea of before and after. *For any given event, there is indeterminacy as to when it occurred or began or ended.* Temporality is itself indeterminate. For Barad, this means “Memory – the pattern of sedimented enfoldings of iterative intra-activity – is written into the fabric of the world. The world ‘holds’ the memory of all traces; or rather, the world is its memory (enfolded materialisation)” (Barad, 2010, p. 261). In discussing these experiments, Barad emphasizes how entanglements entail “irreducible relations of responsibility” (Barad, 2010, p. 265). A diffractive experiment is never a detached observation set in motion merely to confirm an isolated hypothesis. Instead, a new emphasis on experimentation demands a worldly ethics.

More-than-human performativity

Barad (2012c) states very clearly that she is not “applying quantum physics to the social world by drawing analogies between tiny particles and people” for that would be a simplistic misuse of both theory and practice (p.17). She uses the term “trans/materialities” to describe this complex social entanglement (Barad, 2012c, p.16).

Instead of drawing analogies, my method has been to examine the underlying *metaphysical* [emphasis added] assumptions and to understand and elaborate the philosophical structure of the theory. Also, another reason you wouldn’t catch

me drawing analogies between the two domains is because I question this very idea that there are separate domains of existence. (Barad, 2012c, p.17)

According to Barad, the focus on radically different scales of being (the quantum or the galactic) does not limit scientific insights into the everyday life of humans. Contrary to the usual way we approach this topic, she emphasizes that there are not two domains (the microscopic and the macroscopic) with two different ontological principles. Thus she claims that quantum ontology is directly (and not simply analogically) relevant to every day matters. She uses the term “queer” to describe the behavior of quantum particles, not simply to mark their strangeness, but to tap the meaning of the term in academic discourse, where “queering” has become a methodological way of exploring multiplicity in thought.

Although research methods in the social sciences have begun to turn to the more than human in studying intra-activity, Barad suggests this doesn’t go far enough and that we need to “find ways to think about the nature of causality, origin, relationality and change without taking these distinctions [human/non-human] to be foundational or holding them in place.” (Barad, 2012b, p. 32). She speaks of the “world’s performativity” and its “iterative intra-activity,” and contrasts her notion of performativity with that of Judith Butler, who characterizes performativity as citational (rather than iterative). The difference between citation and iteration allows Barad to think of a *more than human* performativity:

The inanimate is always being shoved to the side, as if it is too far removed from the human to matter, but that which we call inanimate is still very much bodily and lively. It may seem perverse, unimportant, or meaningless, to attribute memory to an inanimate happening, but that speaks of a failure of imagination that gets stuck at the threshold of one of the most stubborn of all dualisms – the animate/ inanimate dualism – that stops animacy cold in its tracks, leaving rocks, molecules, particles, and other inorganic entities on the other side of death, of the side of those who are denied even the ability to die, despite the fact that particles have finite lifetimes. (Barad, 2012c, p. 21)

But it’s not simply the non-human world that thrives and mutates, while the mind or the conceptual is kept pure – even theories are living and breathing reconfigurings of the world: “Theorizing, a form of experimenting, is about being in touch ... The world theorizes as well as experiments with itself. Figuring, reconfiguring. Animate and (so-called) inanimate creatures do not merely embody mathematical theories; they do mathematics.” (Barad, 2012a, p. 1-2). Her realism is evident in her claim that the findings of the which-slit and the eraser-slit experiment give “empirical traction” to Derridean theories of trace and texture and performativity (Barad, 2012b, p.44). By diffractively reading Derrida, that is, *by reading Derrida through the findings of quantum physics*, she argues that we are able to produce a new *more empirical* deconstruction.¹ Her diffractive

¹ This take-up of deconstruction marks Barad’s project as quite different, in lineage, from that of Deleuze or other STS and post-humanist philosophers like Bruno Latour. She does use, however, Latour’s terms “matter of fact” and “matter of concern,” and I would argue that her interest in an empiricist texturing of the world aligns with Deleuze and Guattari’s focus on indexical signs in *Thousand Plateaus*.

method brings deconstruction together with the spooky activity of atoms at the quantum scale.

Examining the quantum eraser evidence in light of this posthumanist performative understanding of the nature of nature resolves some of the evident paradoxes and gives deconstructionism empirical traction. To put the point differently, this move makes the wager that the radical reverberations of deconstructionism are not merely perverse imaginings of the human mind or of culture but are, in fact, queer happenings of the world (Barad, 2012b, p. 44).

I take this to be a proposal that “discourse” be treated as a material semiotic and register, a trace or touching, whereby textuality becomes empirical texture:

While the suggestion that deconstruction might have empirical support may seem blasphemous, to say the least (especially given the common understanding that deconstruction has fully deconstructed empiricism and put it to rest, as it were), Kirby, Schrader, and I are insisting on materialist readings of deconstruction that open up the empirical to reworkings that unmoor it from conventional understandings and do not presume that it can (or even ought to) be put to rest. (Barad, 2012b, p. 45-46)

Thus she will go on to describe empirical data as “intelligible speakings of the world” and describe this as a “world worlding itself” (Barad, 2012b, p. 46). Her emphasis on the “speakings” of the world reveals her continued emphasis on discourse, now conceived more materially as trace or register. The indexical register is a kind of sign-making that forms contiguous or material linkages. If language is indexical it is because there are asignifying particles that make up all expression – language is a kind of haptic/touch relation that *inheres* in the world and perhaps *expresses* the world. Quantum ontology, according to Barad, shows us how language and discourse are haptic encounters. Touch in a post-quantum world reaches beyond the conventional phenomenological framing of hapticity, and suggests a massive intimacy across a spectrum of possible envelopments.

The polymorphous field of concepts

Turning to quantum field theory, Barad uses the term “virtual” to describe quantum particles, such as photons, electrons, Higgs-Boson, etc. but also to describe the plane of trans-touching conceptual dynamism from which a concept is actualized. Any concept actualized in any experiment is haunted by the virtual plane of infinite others that are not actualized. If the concept of circle or cube is produced as young children play with various materials, this concept remains tied to this virtual plane of conceptual dynamism. It’s important to note that she does not see the actualized concept as *lacking*, or the act of actualization as a *negation* process. In turning to this virtual dimension of matter, she affirms the *positive* potentiality of the indeterminate. In response to her work, Žižek (2012) offers an alternative interpretation, claiming that quantum indeterminacy marks an inherent negation, lack or denial that is immanent to the world. Barad instead claims that there is no eternal inert void in which particles exist, because the “void” of indeterminacy becomes a “breathing indeterminacy of non-being” (Barad, 2012a, p. 4). Actualized physical particles intra-act with the virtual particles of the field, and are not

independent in the classical sense. In the quote below we see how she builds on Democritus (the founder of atomism and a chance-inflected universe) to rethink the metaphysics of the quantum world, arguing that the void is no longer “vacuous” but populated, becoming a jubilant field of activity and indeterminacy (Barad, 2012a, p.4). Accordingly, a polyamorous touching sustains the world through contiguous haptic encounters between the actual and the virtual. Barad suggests that the quantum self-interference of virtual particles is a kind of “self-touching” that sustains the world. She notes that quantum field theory shows how each “individual” always already includes an infinitude of intra-actions with itself *through the infinitude of virtual others*.

All of this highly metaphysical musing helps us understand the ways that quantum ontology is relevant at the human scale. She reclaims and redefines reflexivity in a more than human world, using the idea of “self-touching” to describe the fundamental polymorphous perversity of the world:

Every level of touch, then, is itself touched by all possible others. Hence, *self-touching is an encounter with the infinite alterity of the self. Matter is an enfolding, an involution, it cannot help touching itself, and in this self-touching it comes in contact with the infinite alterity that it is*. Polymorphous perversity raised to an infinite power: talk about a queer intimacy! What is being called into question here is the very nature of the “self,” and in terms of not just being but also time. That is, in an important sense, the self is dispersed/diffracted through time and being. (Barad, 2012a, p. 5-6)

This infinite (and infinitesimal) entanglement informs Barad’s approach to ethics. Through this emphasis on “polymorphous perversity,” she presents an ethics and a sociality for quantum ontology, and thereby addresses a crucial concern that must be kept at the forefront of any new empiricism. Individuals are indebted to all others through this infinite intra-activity, and this debt, she says, is the condition of all possible giving and receiving. Barad will argue that only through this inhuman virtual indeterminacy can we come to develop an ethics. She follows Derrida and Levinas in proposing an ethics that is prior to all judgment, an ethics that turns on the always already touching of the Other.² She suggests that ethics is not about obligation or intentionality, not a calculation of value or utility, but an infinite responsiveness towards that which cannot be sensed – an openness to the “perverse” touch that is occurring beneath or within all the touching of which you are conscious:

The very nature of matter entails an exposure to the Other. Responsibility is not an obligation that the subject chooses but rather an incarnate relation that precedes the intentionality of consciousness. Responsibility is not a calculation to be performed. It is a relation always already integral to the world’s ongoing intra-active becoming and not-becoming. It is an iterative (re)opening up to, an enabling of responsiveness. Not through the realization of some existing

² At points in her work, although perhaps not this one, we can see ways in which her ethics resonates with that of Spinoza. Various scholars have debated the extent to which the basic ethical positions of Levinas and Spinoza are in disagreement.

possibility, but through the iterative reworking of im/possibility, an on-going rupture. (Barad, 2010, p. 265)

Ethics is thus the capacity to draw on this elemental life that is experienced as inhuman, and to access this inhuman aspect *of human life itself*. We might see this as a kind of eco-ethics that aims to attend to the more than human bonds that sustain a diverse material-culture.

It is worth contrasting her approach with that of Žižek (2012), who adopts Barad's ideas about quantum ontology with some important differences. I offer this comparison in order to better appreciate Barad's contribution to the question of how concepts occupy and perform the world. I also think it essential to offer some detail in this comparison, because Žižek is to some extent a stand-in for a very different theoretical perspective, grounding his work in readings of Lacan and Hegel. This raises once again the issue of whether Barad's work finds an ally in Deleuze or in a very different tradition of Hegelian scholarship represented in the work of Žižek. I explain below how Žižek incorporates particular insights from her work on quantum ontology, but ultimately diverges from what he dismissively calls her "naturalism."³ For Žižek, the question regarding where and how concepts are deployed in world making depends on the structure and force of the Lacanian "symbolic order."

Žižek (2012) pursues *analogies* between the quantum and subjectivity, suggesting that the various double-slit experiments point to the power of the symbolic order, which he takes in this case to be the registering of information about the atoms by measuring devices. Just as in quantum physics, where the actual trajectory of a particle "can only be explained if one takes into account all of its possible trajectories within its wave function," the subject of desire, says Žižek, is formed with reference to a vast sea of possible life trajectories: "In both cases, the actualization does not simply abolish the previous panoply of possibilities: what might have happened continues to echo in what actually happens as its virtual background." (Žižek, 2012, p. 920). Žižek takes up Barad's work and suggests that the quantum world is operating much like we operate, occupied by life trajectories and life histories. Similarly, just as the atom seems to know that it is observed, and then changes its behavior (wave or particle), human subjects alter themselves as they imagine themselves seen by others. Furthermore, the time-warp effect that Barad discusses, in relation to the eraser experiment, is shared with the symbolic order, insofar as subjects, often after some intervention or event, will invest retroactively in re-creating their past. Just as an intervention after an experiment can erase past patterns of the atom on the screen, our self-images and life histories can be entirely rescripted after a hugely significant symbolic event. Such analogies are in fact problematic, as Barad indicates, for they can be naïve projections of physical models from one context to another. These kinds of "subjectivist readings" of quantum phenomenon, in which the symbolic is taken to mask a phantom real, are misleading because they assume that the act of measurement distorts what it measures. If it were

³ It's important to mention here, in terms of framing the debate and understanding its significance, that in 2012 Žižek publically insulted Barad by dismissing her work as a reflection of her lesbian post-modern tendencies. See E. Geerts & I. van der Tuin (2016) for a full elaboration of how Žižek's assessment of Barad reflects an Oedipal dialectical reading (and a politically conservative habit) that runs counter to Geerts and Van de Tuin's diffractive reading.

just a matter of distortion, then one might, in principle, subtract the offending measuring device, and get closer to the Real.

The main point for Žižek (2012), however, is that quantum physics studies the *traces* of sub-atomic particles, the “registering” of matter, and is thus always a kind of language or science of language. The two-slit experiments offer evidence of the *immanence* of the symbolic within the real. He sees in the quantum experiments evidence that the world is always already symbolic. Žižek (2012) asks:

should we risk a step further and claim that there is something which strangely recalls (or points towards) symbolic structures already present in the “physical” reality itself? If we do draw that conclusion, then the entire “spontaneous philosophical ideology” of the gap that separates nature from culture (a form of ideology often clearly discernible in Lacan himself) has to be abandoned. (p. 921).

This claim surely underscores Barad’s emphasis on the empirical texturing and performativity of the world. He claims that the symbolic “touches the Real in a totally immanent way” (p. 959). But the symbolic order carries other implications for Žižek who argues that quantum physics shows that the limitation or lack that characterizes life (and desire) is not limited to the finitude of human beings, but also manifest in the Real. For Žižek our epistemic obstacle – in not knowing the Real – becomes the limitation of the Real itself. In other words, Barad’s fully polyamorous infinite self-touching world becomes for Žižek a world of lack or negation or denial. *Indeterminacy for Žižek is a lack or negation*. This emphasis on lack permeates Žižek’s reading of quantum physics, reflecting his Hegelian commitment to the negation of a positive order of being: “What this means, in effect, is that there is no ontology of the Real: the very field of ontology, of the positive order of Being, emerges through the subtraction of the Real.” (Žižek, 2012, p. 958). He claims instead that there is a “pre-ontological field” where a universal dialectic produces the inherent lack of the Real. In other words, and quite contrary to Barad, Žižek underwrites the world with a negative dialectic, which undermines whatever plane of immanence and pure difference he was able to glimpse in his discussion of quantum ontology.

Realism and relationality

Barad is a realist about concepts insofar as realists are committed to the existence of concepts as more than mere representations of the ‘real’. As Rouse (2016) states, describing Barad’s position: “Conceptual content is not a representation of an object, but a material articulation of a phenomenon, which encompasses both meaning and what is meant.” (p. 5). In denying their role as representations, Barad stands apart from psychological approaches that posit concepts as mental constructs in human minds, and aligns herself with the contemporary turn to various kinds of realisms and materialisms across the humanities.⁴ Harman (2016), however, suggests Barad is far from being a realist because she does not, citing Delanda, “grant reality full autonomy from the human

⁴ Agential realism (Barad), Speculative realism (Harman), Speculative materialism (Meillessoux), New materialism (Frost)

mind.” (p. 5). He describes her as a “relationist” rather than a realist, because she invests in the *relationality of concept and object*. In emphasizing the coupling of matter and meaning, Harman sees Barad as someone who is still trapped in a theory that validates “the constant correlation of world and thought” (p. 7). For Harman (2016), following Delanda, a realist is someone who believes that “the world exists independent of minds”; this absolute independence is necessary, according to Harman, if there is to be change and newness, and any chance of a radical “explosive undercurrent” that belongs to the world (p. 22).

What Harman shares with Barad, however, is an affirmation of an agential non-human world; where they differ is in their understanding of relationality and affiliated terms such as in/dependence. For Harman, any attempt to prioritize “relation” denies the absolute independence of objects and in so doing reveals a tacit desire to re-center the human mind in the world. According to this critique, Barad’s claim that “only relations exist” is a back-door way to ensure the inclusion of the human in an all too comprehensive encompassing of the world. Despite efforts to decenter the human, Harman argues that a relational ontology is always modeled on human conceptions of relationality.

Barad’s quantum ontology, however, presents an entirely non-human relationality that addresses the concern raised by Harman. Moreover, Barad’s realism achieves this without banishing concepts as inadequate mental/linguistic representations of the real. In other words, concepts are imbricated in this non-human ontology. Her relational ontology is not a simplistic correlation between world and thought, but rather a philosophy of immanence which attends to the *active* material nature of concepts. Harman is concerned that her approach is “correlationist” insofar as it entails a projection of consciousness onto and into the universe – i.e. she posits a conceptual matter modeled on the human mind (where mind stands in for desire, affect, cognition and anything else that might be affiliated with human life). He has the same or similar critique for Deleuze. Indeed, one can find sloppy affirmations of a smooth and inclusive “relational ontology” that seem all too self-serving in allowing humans access to everything. All too often, relational ontologies make rather mundane claims about everything being connected or interdependent, without adequately addressing the complex structure of connectivity. I would argue, however, that Barad offers a far more nuanced and complex theory of relationality in a post-quantum world.

Notice how, for Harman, independence between two factors or agents is based on the absence of a *causal* relationship between them. Thus his critique of relationism is actually based on concerns about conventional Newtonian images of causality and connectivity, which operate across spatial extension and temporal linearity. In quantum mechanics and field theory, such images no longer apply. The quantum leap, discussed below, is a perfect example of how connection is not achieved through continuous extension, at least not in the conventional sense of ‘continuous’. In other words, the space-time continuity of extension that we usually assume necessary for a “relation” to hold, especially one of dependence, is no longer necessary.

In Bohr’s model of the atom electrons are said to *leap* from orbit to orbit (energy level) in such a way that they are nowhere in between orbits during such movement. Such leaps betray the rules of conventional movement: “the electron is initially at one energy level and then it is at another without having been anywhere in between! A quantum leap

is a discontinuous movement.” (Barad, 2012b, p. 39). Photons of varying frequency, corresponding to the change in energy level of the leap, are released as the electron moves from orbit to orbit. Thus the photon release is the evidence of movement, and yet the *event* of movement occurred in *no* place. The event happens at a particular time, and yet not in any particular place (for it happens *between* discrete levels, where there is no *continuous* spatial movement, but rather a weird “leap” that is essentially a disappearing act). Moreover, the photon released during the leap is a measure of the energy change (a differential), but under classical physics this measure can only be achieved after the leap is complete.

It is this weird discontinuous leap that makes her suggest that the non-classical ontology of relationality in quantum physics “might yield a different set of insights about human and non-human worlds” (Barad, 2012c, p. 18). The quantum world introduces a new kind of connectedness that doesn’t abide by the old metaphors of relation. Realism has to be redefined in this quantum world. The notion of in/dependence, at the centre of Harman’s definition of realism (in which the world is said to exist absolutely independently of particular minds, and of thought more generally) also needs to be reconceived.

This queer alteration of relationality leads Barad to use the term “cutting together apart” when discussing processes of individuation.⁵ This action of cutting-together-apart is evident in quantum experiments where individual particles which are seemingly autonomous or independent, are yet entangled with each other and able to “intra-act” instantaneously.⁶ Quantum ontology undermines the strict dichotomy between discrete individuation (objects) and continuous connectivity (relations). The queer behavior of quantum leaps is an event that shows us new forms of relationality:

Quantum leaps are not simply strange because a particle moves discontinuously from one place, here now, to another place, there then, but the fundamental notions of trajectory, movement, space, time, and causality are called into question. And the here and there and now and then are not separate coordinates, but entangled reconfigurings of spacetime-mattering (Barad, 2012c, p. 19).

Barad demands that relationality be reconceived based on these experimental findings. Quantum relationality partakes of a connectivity that breaks with classical physical models, troubling human-scale understanding of space-time events. Rather than affirm wo/man’s place in the world, such relationality seems to compose a world indifferent to human action. Then again, if Barad invests in a quantum matter that is “shared” by human and non-human, is she once again performing the anthropocentric move - or at least the anthro-inclusive move – on behalf of her species?

⁵ The work of Barad and Deleuze shares many common interests – including the explicit commitment of each to develop new ways of commingling the continuous and the discrete, essentially a new theory of difference. I therefore disagree with S.F. Heine’s (2016) characterization of Barad’s work as focused on identity and thus entirely at odds with Deleuze’s philosophy.

⁶ Intra-activity is not a form of communication (signal sent and received) but an instantaneous becoming together. The difference is important because the notion of entanglement in physics is not about communication.

Probability plays a pivotal role in quantum ontology, and is indeed at the heart of this new form of relationality - the existence and location of all these leaping particles is bound up with probability measures. An energy orbit is like a sphere of possibility; individuation of electron is studied through the modal logic of inexact location. Thus individuation is achieved in terms of *degrees* of existence, using probabilistic metrics and mathematical formulations of conditional relations. Probability is precisely the conceptual content of the quantum leap, and perhaps also the machinic rumbling that sustains quantum ontology. Notably, however, Barad does not adequately address the absolutely central role of probabilistic reasoning underlying this description of queer quantum behavior. This silence needs attention, as it seems likely that some notion of generative chance, as marshalled within probabilistic forms of activity, may be the key to this new kind of relationality (de Freitas, 2016; de Freitas et al, 2016). If individuation (of objects or concepts) is a process that engages in the powerful force of probabilistic rendering, then more work is needed in unpacking what Hansen (2015) calls this “probability in the wild.”

Concluding comments

I have elaborated the differences between Barad, Harman and Žižek so that we can better discern the complex web of theory that differentiates them. Their different approaches to relationality, experimentation and the symbolic reveal important implications for how concept and matter commingle. Barad’s quantum ontology, with its emphasis on “cutting together apart,” grapples with modal and probabilistic forms of relationality that subvert conventional notions of in/dependence. Harman’s concern that relational ontologies always succumb to an anthropocentric image of relationality fails to adequately consider how Barad’s ontology “rests” on the queer quantum movement of sub-atomic matter.

Barad draws our attention to the pivotal role of experimentation in remixing the polymorphous field of concept-method. She looks for experiments with consequential mattering, experiments that pose a philosophical problem. A diffractive apparatus plugs into a plane of generative philosophical problems that make all the present concepts quake and tremble. This approach recenters philosophical problems as a source of inquiry in the social sciences - problems that force us to question the nature of space, time, number, life. A diffractive experiment investigates our shared quantum ontology by delving into these problems. For Barad, this offers a means to study the empirical traction of Derrida’s trace, not as a symbolic lack, but as a kind of symbolic plenitude. Finally, turning to quantum field theory, Barad posits a textured fabric of universal hapticity that threads the actual and the virtual together. Touch becomes the fundamental relation of the world - a quivering quantum tug that holds us together, rather than a classical physical collision encounter. She claims that this quantum touch stretches across the inhuman field of virtual indeterminacy and can furnish an ethics adequate to the world. She leaves us with the challenge of designing and implementing a set of generative experiments that might pursue that aim.

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